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(54) Title of the Invention:

Apparatus for Manufacturing Optical Components,
Method for Manufacturing Optical Components Using Said Apparatus, and
Projection-type Television Set Using Said Optical Components

(57) Abstract

Problem: To provide a high-productivity apparatus for manufacturing optical components, a method for using said apparatus for manufacturing optical components having good optical characteristics, and a projection-type television set in which said optical components are used.

Means of Solving: A base member 3a of polyethylenenapthalate, etc., loaded on a supply roll 4, is fed through guide rollers 5a, 5b, 5c, 5d, 5e and 5f, to a takeup roll 6. A Si target evaporation source 7a and a Nb target source 7b are alternatingly sputtered. While monitoring with an optical monitor 10, the gas flow rates of argon and oxygen are adjusted to form a layered optical thin-film of a thickness that will provide a prescribed transmittance characteristic in accordance with a predetermined optical design for a configuration such as, for example, a 20-layer optical thin-film structure having 10 layers of SiO_2 alternating with 10 layers of Nb_2O_5.

Claims

[The claimed invention is]

1. An optical component manufacturing apparatus characterized in that it comprises at least

a supply roll having a base member wound thereon;

a takeup roll for taking up said base member as it is fed out from said supply roll; and

an evaporator means for evaporating an optical thin-film source material between said supply roll and said takeup roll;

[wherein] as said base member is fed from said supply roll to said takeup roll, an optical thin-film is formed on said base member by causing said optical thin-film source material to be evaporated by said evaporator means in a reduced-pressure atmosphere.

2. An optical component manufacturing apparatus as recited in Claim 1 characterized in that said evaporator means has a means for providing the capability to selectively evaporate at least two types of said optical thin-film source material having different indices of refraction.

3. An optical component manufacturing apparatus as recited in Claim 2 characterized in that one of said two different-refractive-index optical thin-film source materials comprises a material selected from the group consisting of Si, an oxide of Si, and MgF_2; and the other comprises a material selected from the group consisting of Ti, Nb, an oxide of Ti, and an oxide of Nb.

4. An optical component manufacturing apparatus as recited in Claim 1 characterized in that it comprises a reactive gas introducing means for introducing reactive gas into the interior of said optical component manufacturing apparatus.

5. An optical component manufacturing apparatus as recited in Claim 1 characterized in that it comprises a means for adjusting the pressure of said reduced-pressure atmosphere therein.

6. An optical component manufacturing apparatus as recited in Claim 1 characterized in that said evaporator means is a system selected from the group consisting of a vacuum evaporation deposition system, an electron beam evaporation deposition system, a sputtering system, and an ion plating system.

7. An optical component manufacturing apparatus as recited in Claim 1 characterized in that said supply roll and said takeup roll each has a core diameter of at least 100 mm.

8. An optical component manufacturing apparatus as recited in Claim 1 characterized in that said base member has an adhesive layer formed on a side thereof opposite a side on which said optical thin-film is formed; and a protective film formed over said adhesive layer.

9. An optical component manufacturing apparatus as recited in Claim 1 characterized in that said base member has a hardcoat layer formed in advance on the surface thereof on which said optical thin-film is to be formed.

10. An optical component manufacturing apparatus as recited in Claim 1 characterized in that said base member is a high polymer film selected from the group consisting of polyethyleneterephthalate, polyethylenenapthalate, polymethylmethacrylate, and polycarbonate.

11. A method for manufacturing optical components characterized in that it comprises, as a minimum, a step of evaporating an optical thin-film source material in a reduced-pressure atmosphere as a base member is being fed from a supply roll onto a takeup roll, for forming an optical thin-film on said base member.

12. A method for manufacturing optical components as recited in Claim 11, characterized in that said step of forming said optical thin-film on said base member is followed by a step of bonding said base member to a transparent member; and a step of trimming said base member to a prescribed shape.

13. A method for manufacturing optical components as recited in Claim 12, characterized in that said transparent member is a glass plate.

14. A method for manufacturing optical components as recited in Claim 12, characterized in that it further comprises steps, performed prior to said optical thin-film-forming step, of forming an adhesive layer on at least one main surface of said transparent member; and forming a protective film over said adhesive layer.

15. A method for manufacturing optical components as recited in Claim 11, characterized in that said step of forming said optical thin-film on said base member is followed by a step of bonding said base member to a frame; and a step of trimming said base member to a prescribed shape.

16. A method for manufacturing optical components as recited in Claim 11, characterized in that said optical thin-film-forming step comprises selectively evaporating at least two types of said optical thin-film source material having different indices of refraction.

17. A method for manufacturing optical components as recited in Claim 16, characterized in that one of said two types of different-refractive-index optical thin-film source materials comprises a material selected from the group consisting of Si, an oxide of Si, and MgF_2; and the other comprises a material selected from the group consisting of Ti, Nb, an oxide of Ti, and an oxide of Nb.

18. A method for manufacturing optical components as recited in Claim 11, characterized in that said optical thin-film-forming step uses a method selected from the group consisting of vacuum evaporation deposition, electron beam evaporation deposition, sputtering, and ion plating.

19. A method for manufacturing optical components as recited in Claim 16, characterized in that said optical film-forming step comprises forming at least 10 layers, alternating between layers of each of said two types of optical thin-film source material having different indices of refraction.

20. A method for manufacturing optical components as recited in Claim 11, characterized in that said optical thin-film-forming step comprises a reactive gas introduction step of introducing a reactive gas.

21. A method for manufacturing optical components as recited in Claim 11, characterized in that said optical thin-film-forming step comprises a pressure adjustment step for adjusting the pressure of said reduced pressure atmosphere.

22. A method for manufacturing optical components as recited in Claim 11, characterized in that said base member is a high polymer film selected from the group consisting of polyethyleneterephthalate, polyethylenenapthalate, polymethylmethacrylate, and polycarbonate.

23. A method for manufacturing optical components as recited in Claim 11, characterized in that it comprises a step, performed either before or after said optical thin-film-forming step, of forming an adhesive layer on the side of said base member that is opposite the side on which said optical thin-film is formed; and forming a protective film over said adhesive layer.

24. A method for manufacturing optical components as recited in Claim 11, characterized in that it comprises a step, performed prior to said optical thin-film forming step, of forming, in advance, a hardcoat layer on the surface of said base member on which said optical thin-film is to be formed.

25. A method for manufacturing optical components as recited in Claim 12, characterized in that the indices of refraction of said base member and said transparent member are substantially the same.

26. An optical component manufactured using a base member with optical thin-film formed thereon, fabricated using the optical component manufacturing apparatus of Claim 1.

27. An optical component as recited in Claim 26 characterized in that it is an optical component selected from the group consisting of a dichroic mirror, an edge filter, a bandpass filter, a component with an anti-reflect film, and a pellicle beam-splitter.

28. An optical component fabricated using a base member with optical thin-film formed thereon, fabricated by an optical component manufacturing method as recited in Claim 11.

29. An optical component as recited in Claim 28 characterized in that it is an optical component selected from the group consisting of a dichroic mirror, an edge filter, a bandpass filter, a component with an anti-reflect film, and a pellicle beam-splitter.

30. A projection-type television set characterized in that it uses a dichroic mirror as recited in Claim 27.

31. A projection-type television set characterized in that it uses a dichroic mirror as recited in Claim 29.

Detailed Description of the Invention

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Technical Field of the Invention

The present invention relates to an apparatus for manufacturing optical components, a method for manufacturing optical components using the apparatus, and a projection-type television set in which optical components manufactured by the apparatus and method are used. More specifically, it relates to an optical component manufacturing apparatus characterized in that it forms an optical thin-film on a base member in a reduced-pressure atmosphere, an optical component manufacturing method that uses that apparatus, and to a projection-type television set in which optical components manufactured by the apparatus and method are used.

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Prior Art

In optical components that are made by forming optical thin-films (optical components with anti-reflect films, dichroic mirrors, etc.) at least ten optical thin-film layers are required to obtain good optical characteristics. These optical thin-films include low-refractive-index films such as MgF_2 and SiO_2, and high-refractive-index films such as TiO_2 and Nb_2O_5. For optical components fabricated by forming optical thin-films in normal batch processes, films are formed by evaporating optical thin film source material and depositing it directly on a transparent member (such as a glass plate) in a vacuum chamber, using known film-forming techniques such as vacuum evaporation deposition, or sputtering.

Fig. 6 shows an example of optical characteristics obtainable when films are formed in this manner. Fig. 6 shows measurements of overall transmission characteristics for a dichroic mirror for a projection television

set made by direct formation of optical thin-films on a glass substrate. As shown in Fig. 6, transmittance of 97% is obtained for 525 nm-wavelength light (p polarized light source, 45° angle of incidence). Normally, an anti-reflect process is performed by forming an anti-reflect film on the surface of the transparent member (glass substrate, etc.) opposite that on which the optical thin-film is formed. For large-area substrates, however, the methods described above, in which the optical thin-films are formed directly on the glass substrate in a vacuum chamber, have some problems:

- The space for placing a large-area glass substrate in the vacuum chamber is limited.
- It is difficult to form sufficiently uniform optical thin-films over the entire surface of a large-area glass substrate.
- Only a small number of optical components can be fabricated at one time.
- With this kind of batch process as the only available option, there could be no manufacturing system or method capable of mass production.

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Problem the Invention is to Solve

The present invention was devised with the above problems in mind, and it is therefore an object thereof to provide a high-productivity apparatus for manufacturing optical components, a method for using said apparatus for manufacturing optical components having good optical characteristics, and a projection-type television set in which said optical components are used.

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Means of Solving the Problem

An optical component manufacturing apparatus of the present invention is characterized in that it comprises, as a minimum, a supply roll having a base member wound thereon; a takeup roll for taking up

the base member as it is fed out from the supply roll; and an evaporator means for evaporating an optical thin-film source material between the supply roll and the takeup roll. As the base member is fed from the supply roll to the takeup roll, an optical thin-film is formed on the base member by causing the optical thin-film source material to be evaporated by an evaporator means capable of selectively evaporating, in a reduced-pressure atmosphere, at least two types of optical thin-film source material having different indices of refraction. Preferably, the diameters of the supply and takeup rolls should be at least 100 mm.

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A method for manufacturing optical components according to the present invention is characterized in that it comprises, as a minimum, a step of evaporating an optical thin-film source material, using an evaporator means capable of selectively evaporating, in a reduced-pressure atmosphere, at least two types of optical thin-film source material having different indices of refraction, as a base member is being fed from a supply roll onto a takeup roll, for forming an optical thin-film on the base member. It is preferred that the above optical film-forming process include steps for forming at least 10 layers, alternating between layers of each of the two types of optical thin-film source material having different indices of refraction. It is also preferable that the step of forming an optical thin-film on the base member be followed by a step of bonding the base member to a transparent member such as a glass plate, and a step of trimming the base member to a prescribed shape. For the transparent member, it is also preferable that the method further comprise steps (performed prior to the optical thin-film-forming step) of forming an adhesive layer on at least one main surface of the transparent member; and of forming a protective film over that adhesive layer. It is also preferred that the step of forming an optical thin-film on the base member be followed by a step of bonding the base member to a frame; and a step of trimming the base member to a prescribed shape.

0006

In the optical component manufacturing apparatus and method of the present invention, it is preferred that the optical thin-film source material comprise at least two different-refractive-index optical thin-film source

materials, one of which includes a material selected from the group consisting of Si, an oxide of Si, and MgF_2; and the other of which includes a material selected from the group consisting of Ti, Nb, an oxide of Ti, and an oxide of Nb. It is also preferred that the evaporator means/optical thin-film forming step be selected from the group consisting of a vacuum evaporation deposition system/method, an electron beam evaporation deposition system/method, a sputtering system/method, and an ion plating system/method. It is also preferred that the optical thin-film forming means/step have a reactive gas introducing means/method for introducing reactive gas for the purpose of forming the optical thin-film. It is preferred that the optical thin-film forming means/step also have a means/step for adjusting the pressure of the reduced pressure atmosphere. Also, for the base member, it is preferred to have a step/method (performed before forming the optical thin-film) of forming an adhesive layer on the side of the base member that is opposite the side on which the optical thin-film is to be formed; and forming a protective film over the adhesive layer. Also, for the base member, it is preferred to have a step/method (performed prior to forming the optical thin-film) of forming, in advance, a hardcoat layer on the surface of the base member on which the optical thin-film is to be formed. It is also preferred that the base member be a high polymer film selected from the group consisting of polyethyleneterephthalate, polyethylenenapthalate, polymethylmethacrylate, and polycarbonate.

0007

An optical component [according to the present invention] is characterized in that it is fabricated using a base member on which is formed an optical thin-film fabricated by either an optical component manufacturing apparatus, or an optical component manufacturing method, according to the present invention. It is preferred that such optical component be a dichroic mirror, an edge filter, a bandpass filter, a component with an anti-reflect film, or a pellicle beam-splitter.

0008

A projection-type television set [according to the present invention] is characterized in that it effects color separation using dichroic mirrors (optical components) fabricated using a base member on which is formed optical thin-films fabricated using either an optical component manufacturing apparatus, or an optical component manufacturing method, according to the present invention.

0009

Through the use of an optical component manufacturing apparatus, and a manufacturing method using that apparatus, of the present invention, it is easy to continuously form a uniform optical thin-film on a high polymer film base member such that the [resulting optical component] can be provided with good optical characteristics. It is therefore possible to provide optical components having excellent optical characteristics (components such as, for example, dichroic mirrors, edge filters, bandpass filters, components having anti-reflect films, and pellicle beam-splitters), by fabricating those components using an optical component manufacturing apparatus, and manufacturing method using that apparatus, of the present invention. By using dichroic mirrors fabricated by an optical component manufacturing apparatus, and an optical component manufacturing method using that apparatus, according to the present invention, a projection-type television set having excellent picture quality can be provided.

0010

Mode for Carrying out the Invention

Described below are a manufacturing apparatus and manufacturing method according to the present invention (an apparatus and method for fabricating an optical component comprising optical thin-films formed on a high polymer film base member). Also described is application of such a component in a projection-type television set. In this example, the optical component manufacturing apparatus of the present invention is made up of a vacuum apparatus having a vacuum evacuation system, within which is provided a film transport system for feeding a high polymer film base member from a supply roll through

guide rollers to a takeup roll, at a set speed. Placed opposite the base member, as it is supported by the guide rollers, etc. are at least two evaporation sources (optical thin-film material sources). The material used for one of these two evaporation sources of optical thin-film material is a low-refractive-index material and the other is a high-refractive-index material. The low-refractive index material could be, for example, either MgF_2, or an oxide of silicon, such as SiO_2; while the high-refractive-index material could be either an oxide of Ti, such as TiO_2, or an oxide of Nb, such as Nb_2O_5. For the evaporator means, either a vacuum evaporation deposition system, an electron beam evaporation deposition system, a sputtering system, or an ion plating system can be used. A gas injection valve may be provided in the vacuum system for injecting a reactive gas that will react with the optical thin-film source material used in the evaporation means. When this is done, Si, Ti, and Nb, for example, can be used as optical thin-film source materials for forming the above optical thin-film, and oxygen can be used as the reactive gas. This would form oxides of Si (SiO_2, etc.), Ti (TiO_2, etc.), and Nb (Nb_2O_5, etc.).

0011

To form an optical thin-film, the supply roll is first loaded with a base member: a high polymer film made of a material such as polyethyleneterephthalate, polyethylenenapthalate, polymethylmethacrylate, or polycarbonate. As the base member is fed from the supply roll to the takeup roll via the guide rollers, the above evaporator means evaporates the optical thin-film source material to form an optical thin-film on the base member. At least two optical thin film source materials are selectively evaporated in the chamber as the base member travels from supply to takeup rolls at a fixed rate, with film thickness adjusted to a prescribed thickness that will provide a film having the prescribed transmittance characteristic. The process proceeds as required to form an optical thin-film in accordance with a predetermined optical design, which might consist for example, of 10 low-refractive-index layers and 10 high-refractive-index layers for twenty layers in all. In this case, the optical thin-film source materials might be selectively evaporated by alternating the direction of film travel to and from the takeup and supply rolls [with each layer], and repeating this process [as required until all of the layers have been formed]. The optical thin-film formed as

the bottom layer (the thin-film layer formed directly on the base member) could be either SiO_x or TiO_x (where $_x$ is an integer no greater than 2).

During the optical thin-film forming process, the pressure of the evaporation atmosphere can be adjusted by controlling the flow rate of the argon plasma source gas and oxygen into the evaporation means. A base member that has a hardcoat layer formed on its thin-film forming surface may also be used. Also, an adhesive layer covered by a protective film may be formed on the base member either before or after forming the thin-film.

0012

Finally, to complete the optical component (dichroic mirror, edge filter, bandpass filter, optical component with anti-reflect film, etc.) a transparent member can be prepared from a glass substrate, for example, and laminated (through an adhesive interface) with a base member on which an optical thin-film has been formed using the thin-film forming apparatus as described above. The transparent member can be prepared in advance by forming an adhesive layer on it, and then forming a protective film over the adhesive. Also, an optical component such as a pellicle beam-splitter can be fabricated by bonding, for example, a circular frame to a high polymer film base member having an optical thin-film formed on it, through an adhesive. Dichroic mirrors fabricated by the above optical component manufacturing apparatus and the above optical component manufacturing method using that apparatus, can be used for projection television.

0013

Embodiment

An embodiment of the optical component manufacturing apparatus, optical component manufacturing method, optical component, and projection television set of the present invention will be described below, using an example in which an optical thin-film is formed for a dichroic mirror of a projection television set.

First, the optical thin-film forming apparatus and manufacturing method will be described using Fig. 1, which is a simplified cross-section view showing an example of a thin-film forming apparatus for forming optical thin-films on a high polymer film base member. Provided in the optical thin-film forming apparatus 1 having a vacuum evacuation system 2, is a film transport system for transporting a high polymer film base member 3a at a set rate of speed from a supply roll 4 past guide rollers 5a, 5b, 5c, 5d, 5e, and 5f, to a takeup roll 6. A sputtering system, for example, may be used as an evaporator means. Two different evaporation sources 7a and 7b (e.g., targets of Si and Nb, respectively) are provided opposite the guide roller 5d, as the optical thin-film source material. Also, a plasma electrode 8 is placed opposite the base member 3a, between the guide rollers 5a and 5b, as a pre-process device for outgassing, etc., of the base member 3a. Provided in the vacuum system is a gas injection valve 9 for adjusting the flow rate of {a gas such as argon, and a reactive gas such as oxygen \1}, during sputtering. Although not shown in the drawing, the guide roller 5d is designed to provide cooling to prevent overheating of the high polymer film base member 3a during film-forming.

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Next, the use of the optical thin-film forming apparatus 1 for forming an optical thin-film for a dichroic mirror in a projection-type television set will be described. The supply roll 4 is loaded with a base member 3a (a 188 μm-thick polyethylenenapthalate film) which is then threaded from the supply roll 4, through the guide rollers 5a , 5b, 5c, 5d, 5e, and 5f, to the takeup roll 6. Next, the evaporation source 7b, a Si target, is sputtered while adjusting the argon and oxygen gas flow rates, to effect the formation of SiO_x (where x is an integer no greater than 2) on the base member 3a. Next, the other evaporation source 7b, an Nb target, is sputtered in alternation with the sputtering of Si target evaporation source 7a as progress is monitored by the optical monitor 10, and the flow rates of the argon and oxygen gases are adjusted to the thickness required to achieve the prescribed transmittance characteristic. This process continues until an optical thin film having a layer structure defined in advance by optical design is obtained. In this example, the designed structure is that of Table 1, with 10 layers each of SiO_2 and Nb_2O_5 optical thin-films (SiO_2 being included in SiO_x), for a total of 20 layers. During the sputtering process, the gas injection valve 9 is

used to adjust the argon and oxygen gas flow rate so as to change the pressure to establish conditions for low reaction of the thin film. For example, by adjusting the pressure used for sputtering (normally around 0.3 Pa) to approximately 1.6 Pa, internal reaction within the overall optical thin-film can be minimized while adjusting for a balance between SiO_2 and Nb_2O_5 reactions, and at the same time reducing curling of the base member 3a film. The base member 3a is prepared for use in advance by forming a 'hardcoat' on its optical thin-film-forming surface, and on its other side (the surface opposite the thin-film-forming surface), forming an adhesive layer covered by a protective film. The base member in this example is a polyethylenenapthalate film. This material stands up well to heat and experiences very little thermal distortion: properties that are conducive to the formation of uniform optical thin films. For example, polyethylenenapthalate has a glass transition temperature of 110°C, compared to only 69°C for polyethyleneterephthalate. From this it can be inferred that polyethylenenapthalate will tolerate high temperatures extremely well.

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Table 1

Layer	Material	Thickness (nm)
1	SiO_x	Approx. 1
2	Nb_2O_5	98.4
3	SiO_2	144.8
4	Nb_2O_5	84.9
5	SiO_2	141.4
6	Nb_2O_5	79.2
7	SiO_2	134.9
8	Nb_2O_5	86.8
9	SiO_2	118.0
10	Nb_2O_5	84.5
11	SiO_2	134.2
12	Nb_2O_5	79.1
13	SiO_2	138.5
14	Nb_2O_5	79.9
15	SiO_2	133.6
16	Nb_2O_5	80.0
17	SiO_2	145.5
18	Nb_2O_5	81.5
19	SiO_2	127.9
20	Nb_2O_5	105.1

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Next, a glass plate (e.g. 5 cm wide, 8.75 cm long, and 1 mm thick) is prepared as a transparent member. This transparent member is laminated by bonding it through an adhesive to the base member 3a having an optical thin-film formed thereon, as described above. The base member 3a is then trimmed to conform to the outline shape of the glass plate, thus completing the fabrication of an optical component for use, for example, in a dichroic mirror of a projection-type television set. A transparent member that has been prepared in advance with an adhesive layer covered by a protective layer, may also be used. An optical component, manufactured by the above manufacturing method for a dichroic mirror to be used in a projection-type television set will now be described with reference to the simplified cross-section configuration diagram of Fig. 2. As shown in Fig. 2, a polyethylenenapthalate base member 3a is bonded to a glass plate transparent member 21 by an adhesive layer 22, and a hardcoat layer 3b is then formed on top of the base member 3a. This is followed by a 20-layer lamination consisting of alternating layers of low- and high-refractive index films: ten layers of low-refractive-index material (nine SiO_2 layers 3c and one SiO_x layer 3c' {(where SiO_2 is included in SiO_x) \2} alternating with ten layers of high-refractive-index Nb_2O_5 layers 3d.

Also, as shown in the simplified diagrams of Fig. 3a and 3b, an optical component for a pellicle beam-splitter 30 can be made, for example, by bonding a circular frame 31, through an adhesive, to a base member 3a on which the above optical thin-film is formed.

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Figures 4 and 5 show transmittance plots for optical components fabricated for use in dichroic mirrors by the above manufacturing apparatus and method. Fig. 4 shows a rough theoretical transmittance characteristic for a dichroic mirror formed on polyethylenenapthalate, assuming no rear surface reflectivity. Fig. 5 shows a rough plot of actual transmittance measurements performed on a dichroic mirror formed on polyethylenenapthalate bonded to a glass plate. In both cases the light source is p polarized light incident at an angle of 45°. According to the measured transmittance characteristic of Fig. 5, the transmittance of this

dichroic mirror for 525 nm-wavelength light is 90%, which is sufficient to meet the applicable performance requirement for a dichroic mirror for projection television. In the present case, the total scattering at 525 nm was 1%, and the total absorption was approximately 3%. Also, the near-equal refractive indices of the glass and high polymer film result in reduced residual transmissivity loss of approximately 4.5%. In addition, the optical thin-film forming process for this dichroic mirror was optimized for minimum absorption within both the high polymer film material and the optical thin-film, thus also providing a reduction in total absorption. Also, in dichroic mirrors produced for use in projection television, for p polarized light at a 45 degree angle of incidence, the glass substrate back surface reflection was an extremely low 1.5%, and it is thought that this could eliminate the need to perform an anti-reflect process on the substrate rear surface.

0018

Effect of the Invention

Through the use of an optical component manufacturing apparatus, a manufacturing method using the apparatus, and optical components manufactured by this apparatus and method (all of the present invention), high productivity in the manufacture of optical components can be achieved; and it will be possible to provide optical components having excellent optical characteristics, and projection television sets having excellent picture quality.

Brief Description of the Drawings

Fig. 1 is a simplified cross-section view showing an example of a thin-film forming apparatus in one mode for carrying out the present invention.

Fig. 2 is a simplified cross-section view of a dichroic mirror configuration, showing a configuration example for an optical component of the present invention.

Fig. 3 shows an example of an optical component of the present invention, where (a) is a simplified plan view, and (b) a simplified end view, of a pellicle beam splitter.

Fig. 4 shows the rough theoretical transmittance characteristic for a dichroic mirror in an example of an optical component of the present invention.

Fig. 5 shows the rough plot of transmittance measurements performed on a dichroic mirror in an example of an optical component of the present invention.

Fig. 6 shows a rough plot of transmittance measurements performed on a dichroic mirror in an example of a prior art optical component.

Reference Numbers

1: Optical thin-film forming apparatus	2. Vacuum evacuation system	3a. Base member
3b. Hardcoat layer	3c, 3c' Low-refractive-index layer	3d. High-refractive index layer
4. Supply roll	5a, 5b, 5c, 5d, 5e, 5f. Guide roller	6. Takeup roll
7a, 7b. Evaporation source	8. Plasma electrode	9. Gas injection valve
10. Optical monitor	20. Dichroic mirror	21. Transparent member
22. Adhesive layer	30. Pellicle beam-splitter	31. Frame

Drawings

Fig. 1

1. Optical thin-film forming apparatus
2. Vacuum evacuation system
3a. Base member
4. Supply roll
5d. Guide roller
6. Takeup roll
7a, 7b. Evaporation source
8. Plasma electrode
9. Gas injection valve
10. Optical monitor

Fig. 2

3a. Base member
3b. Hardcoat Layer
3c, 3c' Low-refractive-index layer
3d. High-refractive index layer
20. Dichroic mirror
21. Transparent member
22. Adhesive layer

Fig. 3

3a. Base member
30. Pellicle beam-splitter
31. Frame

Fig. 4, 5, and 6

(Y axis) Transmittance (%)
(X axis) Wavelength (nm)